INTERFACING ECONOMIC AND DEMOGRAPHIC MODELS FOR RURAL AREAS: DESIGN AND METHODOLOGICAL CONSIDERATIONS

Steve H. Murdock, F. Larry Leistritz, and Lonnie L. Jones

Recent increases in the number of resource and industrial developments in rural areas [10] have led to the creation of a large number of comprehensive planning models usually identified as "economic-demographic" projection models [see for example 1, 3, 4, 5]. These models are used to delineate systematically the interrelationships among various economic, demographic, and social factors. They differ in their basic model structure, their degrees of flexibility, and range of user input options, and in terms of the geographic and governmental units for which projections are made. Each, however, includes a basic economic module, a demographic module, and a module for interrelating or interfacing the economic and demographic modules. Additional modules, such as fiscal impact, settlement allocation, public service, and housing demand modules, also may be included but they tend to operate directly on the outputs of one of the other three basic components and are thus largely addendums to the economic, demographic, or interface modules of such models.

The key to the development of a truly integrated systems-based economic-demographic model is in the design of the interface component. The interface normally includes functions for matching employment demands with available local labor force and for using the results of that matching procedure to determine the levels of migration and population change likely to result from an excess of employment demands or an excess of available labor. The range of actual methods used in performing these functions and the detail with which each is performed differ greatly from one model to another. Few analyses of the essential characteristics of interface components and few attempts to develop methods specifically oriented to a predetermined set of design considerations have been undertaken. Because such components form the basis of integration in economic-demographic projection models and are one of the major factors indicating the level of development of multidisciplinary systems-based models, the lack of such studies is indeed unfortunate.

The purpose of this article is to examine the major considerations that must be taken into account in the design of interface components of economic-demographic impact projection models and to describe one method which the authors believe fulfills many of these design considerations.

DESIGN CONSIDERATIONS

Major considerations in the design of interface modules are to ensuring that such modules are inclusive, flexible, integrated, recursive, capable of accurately reflecting a wide range of changes resulting from developments [12] and to ensuring that such policy models, when applied to environmental or other assessments, are in fact oriented to key policy issues and dimensions [7] and to fulfilling environmental impact assessment requirements [2]. Beyond these general considerations, major design considerations must be oriented to ensuring that all components of the model effectively simulate rural conditions and the events likely to occur in a rural area during development of a major project. For interface components this means ensuring that those factors likely to affect the interrelationships among employment, migration, and population change such as employment demands, labor force availability, and employment-related population impacts are included in the module. Specifically, it is essential that interface procedures:

1. Be employed consistently for performing both baseline and impact projections.
2. Use data that are specific to the local area and the characteristics of demographic structure in the local area.
3. Differentiate among the various forms of employment demands.
4. Accurately assess local labor force availability and employability for each of the types of employment demands.
5. Use estimators of population characteristics that are specific to various worker types.

Steve H. Murdock is Assistant Professor, Department of Rural Sociology, and F. Larry Leistritz and Lonnie L. Jones are Professors, Department of Agricultural Economics, Texas A&M University. The work was supported by the Texas Agricultural Experiment Station and the Center for Energy and Mineral Resources, Texas A&M University.

Such design features increase both the model's accuracy in simulating rural baseline and impact conditions and its utility for policy makers. Each of these factors is discussed briefly.

Baseline Projections

One of the crucial considerations is the establishment of the component's ability to simulate baseline interrelationships. Although it might appear obvious that impacts cannot be established without an adequate understanding of non-impact events, several of the models now available do not have an interface component for baseline projections. Rather, employment projections are based on standard input-output or export base techniques with rates of fertility, migration, and mortality being assumed to follow some pattern related to historic trends. The questions of whether the employment projections are likely to be correct given the demographic structure of the area or whether the population economic base are simply not examined [9, 11]. In addition, because these projections are in turn compared with impact projections in which interface components are used, one cannot discern whether baseline-impact differences are real or a function of the use of different methods.

Areal and Age Specificity

For many rural areas the history of past population change has been one of population decline, heavy out-migration, and high fertility. These events have led to demographic structures that are very different from area to area and that depart markedly from standard population structures. For discerning changes in such areas over time, two widely used procedures thus seem problematic. First, for many projections of impact and baseline conditions, ratios of national, state, or regional employment to population [9] are used, but these ratios are likely not to be accurate for many rural areas and do not allow one to take variations in individual areas into account. Second, even when local values for the total population are used, wide differences in the age distribution of persons in rural areas may make general assumptions about the number of available employees in an area questionable. Only if elements of the local age structure are taken into account can one be assured that employment projections will reflect demographic realities.

The input of areal-specific values tends to increase the specificity with which outputs can be produced and hence increases the range of potential users. School administrators and social service personnel, for example, require data that have at least age detail. In sum then, both the accuracy of the interface procedure and the use of the model are likely to increase with increased use of areal and age detail.

Differentials in Employment Demands

The nature of employment changes in rural areas under development conditions must be considered a multifaceted phenomenon. That is, the employment demands created by a development are diverse and include at least four types of employment needs: employment requirements resulting from baseline economic activities, direct employment related to the construction of a given facility, direct employment necessary for the operation of the facility, and indirect employment resulting from the development. Because the skill levels and demands through time for such employment types are different, it is essential to maintain the separate nature of these employment types within the interface procedure.

Differentials in Local Labor Availability

It is equally important to recognize that the availability and skill levels of the local labor force are also multifaceted phenomena. Studies of employment patterns during industrial developments [13] show that labor forces in rural areas generally have low skill levels and that projects with higher demands for unskilled labor usually result in higher proportions of local persons being employed. Local labor availability, however, does vary greatly for different types of employment. The inclusion of occupational or other skill level indicators for the local population in the model is as essential as the inclusion of differentials in employment demands.

Specificity of Demographic Characteristics

The need to account for differences in the likely characteristics of persons moving into an area during a development is also apparent. Too often the indigenous employees who leave an area because of inadequate employment demands and the new in-migrating construction workers, operational workers, and indirect workers are assumed to have identical characteristics. The characteristics of such groups have been found to be very different [13] and such differences may negate the accuracy of otherwise effective projection techniques. For many areas of the Northern Plains, for example, many initial projections of the population changes resulting from the construction impacts of energy developments were highly inflated because of the assumption that construction populations would have average family sizes as large as those of indigenous populations. It is essential, then, that effective interface procedures be designed to allow for the input of different sets of characteristic estimators for different types of worker-related populations.

A METHOD FOR INTERFACING ECONOMIC AND DEMOGRAPHIC MODELS

The Basic Model

The basic model is similar in form to one developed by several of the authors and others at North Dakota State University under the auspices of the North Dakota Regional Environmental Assessment Program. It is used in that agency's Economic-Demographic Projection models (RED-I, II) and is being employed in a model now under development at Texas A&M University.[1]

The model consists of six major components: an economic input-output module, a demographic cohort-survival module, a gravity allocation module, a fiscal impacts module, a public services impact module, and the interface module. The economic module provides projections of employment requirements by type of employment and sector, the demographic module provides projections of available labor by type, age, and sex, the gravity allocation module allocates employment to specific locations, the interface component matches labor availability and demand, and the fiscal and public service modules provide local projections in their specified impact service areas based on the economic and population values from the other model components. The model provides projections of such factors as gross business volume, per capita income, employment, population by age and sex, revenues and expenditures by type, school enrollment, medical service requirements, and criminal justice service requirements at the regional, county, and community level for each year during the development.

The model is fully interactive and has been used extensively by public and private concerns in North Dakota. Since its completion in October 1976, it has been used by 55 different groups, including the State Senate Finance and Taxation Committee for the determination of the implications of alternative severance tax rates, the State Highway Department for the determination of road resurfacing requirements, the U.S. Bureau of Land Management for the determination of the regional impacts of western coal development, several local communities for the determination of service requirements for schools, sewer systems, and other public services, and by several private concerns for completing impact assessments.

The model is now being extended and validated in North Dakota and is being adapted or is under consideration for adaptation in Texas, South Dakota, and Alaska. Its basic structure is appropriate for assessing the impacts of many types of development projects including energy development projects, agribusiness developments, rural manufacturing developments, and water resource and irrigation developments. Additional information on the total model structure and details of the interface procedure are available from selected sources [4, 6].[2]

The Interface Component

The interface module is applied at the county level, is fully employed in both baseline and impact projections, and operates with the following order of structural components and procedures (see Figure 1).

1. Estimates of the number of employees required to fill baseline, construction, operational, and indirect types of employment are maintained as separate inputs from the economic input-output model and from data on project characteristics (baseline and indirect from the I-O and direct from project data). Under baseline conditions, of course, only projections of baseline employment are produced.
2. During baseline projection periods and in the year preceding project construction, estimates of the number of available workers are obtained by the application of county level age-sex-specific labor force participation rates to age-sex cohorts derived as products from the demographic model. This step produces the number of total workers available in each age-sex group for that period. Under impact conditions a similar procedure is followed. However, age-sex-specific estimates of available labor pools are obtained for each of the baseline, construction, operational, and indirect types

[1]The Texas model is being developed through a cooperative agreement between the North Dakota Regional Environmental Assessment Program and Texas A&M and is largely an adaptation of the structure of the North Dakota model. However, the Texas model will include an expanded economic base and an environmental module not present in the North Dakota model. Though the computational steps used in the models' interface procedures are identical, this article is the first written description of the conceptual basis for the models' interface procedures.

[2]Persons desiring additional information on the model may obtain copies of the technical documentation for the North Dakota model by writing the North Dakota Regional Environmental Assessment Program, 316 North 5th Street, Bismarck, North Dakota 58505. Those wishing additional information on the Texas adaptation of the model should contact the authors directly.

for each period by the application of age-sex employment-type-specific labor force participation rates to age-sex cohorts for each type of employment-related population. Throughout the impact analyses, these employment and population types are retained as separate computational units.

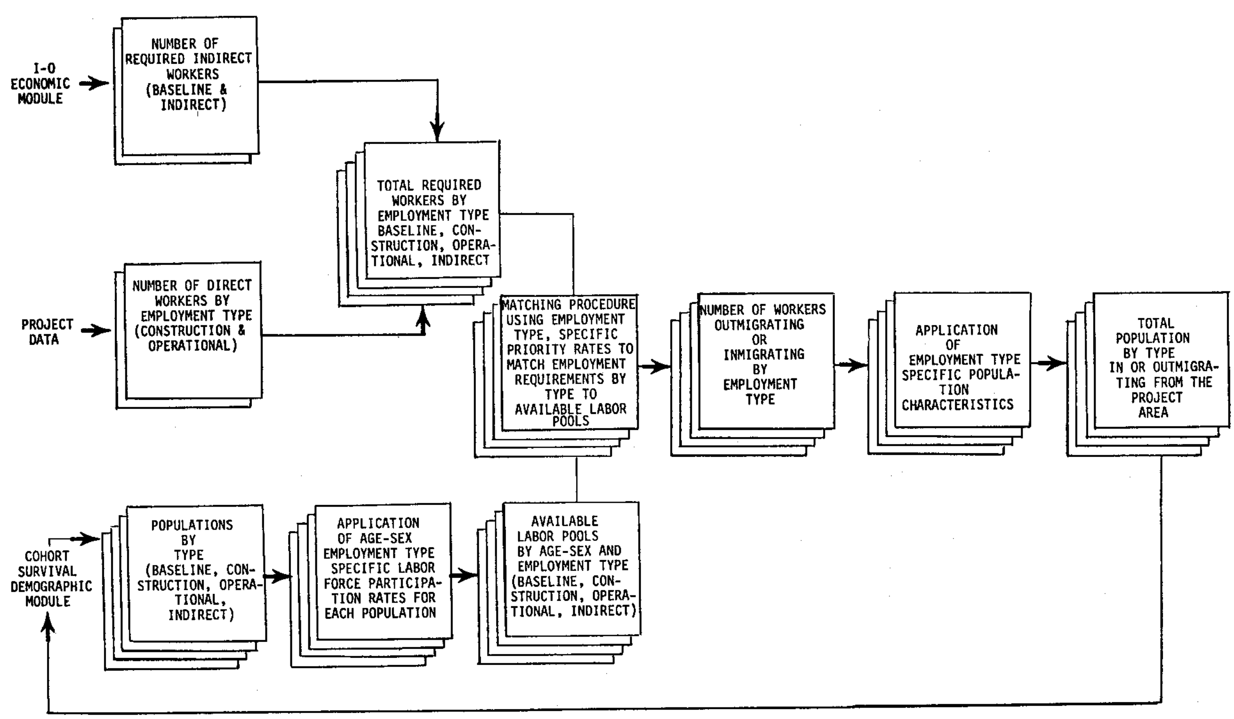
3. Given the employment-type-specific labor requirements as derived from Step 1 and the age-sex employment-type-specific estimates of available labor from Step 2, a matching procedure is used which takes required employment from available employment pools in accordance with a predetermined employment-type priority schedule. This schedule, shown in Table 1, is an attempt to incorporate estimates of the differential abilities of various kinds of workers to fill various kinds of employment. For example, as shown in Figure 2, it is assumed that baseline indigenous jobs can be filled only by persons from the available baseline labor pool. For operating jobs a specified proportion is assumed to in-migrate because of special skill requirements. Given that this proportion has been set aside, other jobs are filled first from the available indigenous population, then from construction populations, and then from other operating worker populations. Employment requirements are filled from each age-sex group within each population type according to the proportion of each age-sex group to the total available labor within that population type.[3]

TABLE 1. SEQUENCE AND PRIORITIES FOR JOBFILLING BY POTENTIAL JOBHOLDERS

Job Sector	Potential Jobholder from Population Group
Baseline Jobs	1. Indigenous population[a]
Construction Jobs	1. Construction worker population in specified fraction of jobs
	2. Indigenous population
	3. Construction workers (in- or out-migration to balance)
Operating Jobs	1. Operating worker population in specified fraction of jobs
	2. Indigenous population
	3. Construction workers' associated population
	4. Operating worker population (in- or out-migration to balance)
Indirect Jobs	1. Indirect worker population in specified fraction of jobs
	2. Indigenous population
	3. Operating worker population
	4. Construction worker population
	5. Indirect population (in- or out-migration to balance)

[a]Out-migrate indigenous population after the employment needs for all job sectors including indirect jobs are satisfied.

FIGURE 1. FLOWCHART OF INTERFACE MODULE OF ECONOMIC-DEMOGRAPHIC MODEL.



[3]Although this procedure requires the use of a number of simplistic assumptions about the mechanisms operating in rural labor markers, little evidence is available that does specify the nature of such mechanisms in rapidly developing areas. The procedure used is seen as a tentative attempt to specify the basic dimensions of such mechanisms. Its structure, however, is designed to be flexible and is capable of being altered as additional information becomes available.

4. As a result of procedure 3, all labor force requirements that can be filled from the available pool are determined. If the labor pool available exceeds that required, out-migration is assumed to occur, whereas an excess of labor requirements over available labor is assumed to trigger in-migration.
5. The results of steps 3 and 4 provide estimates of the number of workers by age-sex employment type who must out-migrate or in-migrate.
6. The numbers of workers by age-sex and employment type are converted to population estimates by the application of a set of employment-type-specific population characteristics to the number of workers of each type. Thus, for each of the baseline, construction, operational, and indirect worker types there is an associated set of data used to estimate the characteristics of sex, marital status, presence or absence of family in the impact area, age distribution of other workers in the household, age distribution of workers, and age distribution of dependents. The end result is the total number persons by age and sex who will either leave or in-migrate for an area for each project period.
7. The population figures determined in Step 6 become the inputs for the next iteration of the demographic module.

The interface component thus described meets many of the criteria noted heretofore. That is, it is used in both baseline and impact projections. It uses data that are specific to the individual county and that are specific to the age-sex demographic structure of the population of the county. Its employment requirement and available labor estimates provide separate functions for the various types of employment that occur under impact conditions. It attempts to assess both local labor force availability and skill levels by the use of labor force participation levels to obtain availability estimates and an employment priority schedule to assess approximate skill levels. It provides extensive detail on the characteristics of new populations and thus provides flexibility in the forms of data outputs and hence their potential subsequent uses.

SUMMARY AND CONCLUSIONS

The assessment of the likely impacts of resource and industrial developments has led to increasing demand for computerized comprehensive impact assessment models. Although several such "economic-demographic" assessment models have been developed, many lack truly integrated interface functions. Such components can be effective in wider models aimed at assisting policy makers only if they allow one to simulate accurately baseline and impact conditions and if they provide outputs with a sufficient range of data to be useful to a variety of decision makers.

The interface procedure described is an initial step toward the development of more effective interface procedures for impact models. Further refinement is essential, but the procedure clearly merits additional examination. Although any attempt to model future events involves numerous potential sources of error, the need for planning tools that can be used to anticipate effectively the interrelationships of various aspects of such developments is evident. Systems-based models such as those described are one answer to this need. The quality of such models is related directly to the accuracy with which they can simulate actual processes occurring under baseline and impact conditions. Attempts to improve the design of interface and all other components of such models must be actively encouraged and pursued.

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